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Southern Africa as a remote sensing test bed: the SAFARI 2000 Special Issue overview

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NASA's flagship Earth Observing System (EOS) Terra satellite was launched in 1999 and began sensing in March 2000 coincident with the first major field campaign of the Southern Africa Regional Science Initiative (SAFARI 2000). Terra's five sensors were used to support SAFARI 2000 studies on the southern African environment, and SAFARI 2000's ground, aircraft and independent satellite data sets were used in turn to validate and improve the remote sensing products derived from Terra. In this article, we review southern Africa's natural and cultural features that we believe formed an optimal environment in which to test the EOS program (including new sensors, products, validation, scientific research, education and outreach). Through the course of the text, we reference and summarize the articles in the SAFARI 2000 Special Issue to highlight the natural links between remote sensing science and the subcontinent's characteristics. We also note contemporary forces of change in the southern Africa landscape whose impacts will challenge the remote monitoring capabilities of future sensors and scientists. The article concludes with a brief description of SAFARI 2000 data resources and access provisions.

1. Introduction

Africa is experiencing rapid and substantial social, economic, and environmental change (UNEP 2002). Some studies suggest that this pattern will continue or intensify. For example, recent climate predictions suggest Africa could be 2–6°C warmer in 100 years' time; rainfall changes are more uncertain (Hulme *et al.* 2001). It is unclear how Africa's ecosystems will respond to such changes. Southern Africa may be especially vulnerable due to the dynamics of its climate, human demographics and disturbance regimes, such as herbivory and fire. Some models of the region suggest ecosystem instability could occur, particularly in the extensive semi-arid areas (e.g. Joubert *et al.* 1996). The instability may be compounded by the strategies that inhabitants use to adapt to environmental and socio-economic changes (IPCC 2001). The perceived threats to the regional ecology and climate have led the World Meteorological Organization (WMO; Easterling *et al.* 2003), the Intergovernmental Panel on Climate Change (IPCC 2001), and the International Geosphere Biosphere Programme (IGBP; Scholes and Parsons 1997) to prioritize southern Africa as a focus for scientific assessment (e.g. Schulze *et al.* 1993).

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To help address the uncertainty, researchers from southern Africa collaborated with the wider international science community to organize and conduct the Southern Africa Regional Science Initiative (SAFARI 2000). The aims of SAFARI 2000 were to identify and understand the linkages between land–atmosphere processes in southern Africa, and in particular to study the relationship of biogenic, pyrogenic and anthropogenic emissions and the consequences of their deposition to the functioning of the region's biogeophysical and biogeochemical systems (Swap *et al.* 2002a). SAFARI 2000 was developed around existing activities and was designed to pool resources and exploit modern field, aircraft and space-based instrumentation. The Initiative emphasized new space-borne observatories, inter-disciplinary teamwork and cross-border studies. Its implementation provided measurements at different scales over 4 years (1999–2002) with intensive campaigns held during the 2000–2001 wet and dry seasons. The 2000 wet season campaign (Otter *et al.* 2002) was timed to assess land and atmospheric properties during peak green biomass conditions, and the dry season campaign (Swap *et al*. 2002b) was timed to coincide with the subsequent peak biomass burning period.

With the operations of NASA's flagship Earth Observing System (EOS) Terra satellite commencing in early 2000, SAFARI 2000 also provided the first comprehensive test of NASA's EOS. EOS is the implementation arm of the Mission to Planet Earth Program (MTPE), conceived in the 1980s, later renamed the Earth Sciences Enterprise (ESE) program (NASA 1999) and now part of the Earth–Sun System Division. The ESE program mission was to integrate the Earth and environmental sciences into an interdisciplinary study of earth system science (NASA 1996). This necessitated advances in earth process modelling and data assimilation, satellite observation technology, remote sensor instrument design and calibration, systematic generation and distribution of high volume satellite products, and quality assessment and validation of the products (NASA 1999).

5. Conclusions

Southern Africa landscapes span the range from stable to fluctuating, fertile to barren, parched to flooded, and economically developed to underdeveloped. Although the region sometimes presented logistical challenges to field investigators, it compensated by providing a rich set of remote sensing targets and test opportunities due to its unique features, including (1) a vigorous biomass burning regime and resultant atmospheric loading seasonality, (2) extensive undeveloped shrublands, savannahs and woodlands overlaying consistent sandy soils (Kalahari sandsheet), (3) low topographic relief, (4) a 4 month 'dry season' of low cloudiness, (5) an extensive inland river delta (Botswana's Okavango Delta) subject to seasonal flooding, and (6) climatic, landform, and biotic gradients. The SAFARI 2000 studies comprising this and the companion Special Issues led to numerous modifications to EOS algorithms, validation protocols, and data handling, as well as EOS-based scientific discoveries. SAFARI 2000 efforts in public outreach—particularly to regional educational institutions and governments—helped make EOS goals tangible to the public. In sum, the execution of the SAFARI 2000 science initiative amid a natural remote sensing test bed led to a comprehensive and effective evaluation of the EOS system. The region's environment and sustained field observation capability can benefit the validation programs for other remote sensing systems.